In Praise of a Historical Storytelling Approach in Science Education

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Abstract: In the 1970s and 1980s, the use of history of science in science education was controversial. In the three last decades attitudes have changed, but the question of best practice has not been definitively answered: What type of historical knowledge should be incorporated in pedagogical contexts, and how? This essay discusses features of historically informed narratives that are suitable for teaching science from upper secondary education on, looking in particular at cases in the history of biology. The essay argues that such narratives should focus on the evolution of fundamental concepts and theories in a given scientific discipline, not on the life and work of one or a few scientists; that a story's historical content must be carefully selected and heavily contextualized in order to serve pedagogical needs; and that storytelling techniques should be actively used to engage students.

THE TURNING TIDE: BRINGING HISTORY TO SCIENCE EDUCATION

Current skepticism regarding the use of history of science in science education often overlooks an important historical fact. Historical knowledge did not become a preferred tool to teach science in the decades that followed Stephen Brush's infamous and much-commented-on 1974 article—"Should the History of Science Be Rated X?"—but the scarcity of historically informed science education did not prevent growing criticism of science.[1] Controversies sustained by specialists in a dozen or so academic publications, such as the so-called Science Wars of the

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[1] For an overview of the cases of Britain and the United States see Michael R. Matthews, *Science Teaching: The Contribution of History and Philosophy of Science*, rev. and expanded ed. (New York: Routledge, 2015), pp. 112–117. It should be noted that

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1990s, have been overemphasized at the expense of a more obvious observation: standard pedagogical approaches to science education have been poorly effective.[2] Science education has often taken the shape of presenting excessively theoretical, abstract, and dry forms of knowledge. This technocratic approach relates to the science that we study, as historians, in the same way that a skeleton displayed in a museum relates to the living animal from which it derived. By the 2000s even Brush was stating that "in science education, the historical approach can no longer be considered just a distraction that takes time away from learning 'real science.'"[3] A broader change in perception had taken place.

The problems of a technocratic science education have already been targeted by various initiatives that recruited historical knowledge to overcome them. At least two large international communities have been discussing new strategies, especially in periodically organized international congresses and in journals such as *Science and Education*. Several of the scholars involved have concentrated on the development of historical case studies for the classroom.[4] The main advantage of these proposals is that they can be easily incorporated in the science courses of educational systems with quite distinct structures. By the time students need to have a broader picture of a scientific discipline (say, from upper secondary education on), however, these case-study approaches are insufficient because they typically focus on the work of one or a few actors and overemphasize the social and cultural contexts of scientific discoveries.

I propose here a blueprint for a different science pedagogy informed by history, one that aims to explain the long-term evolution of knowledge in scientific disciplines. This pedagogy has *concepts* rather than scientists as its themes and spans *several decades or centuries* rather than shorter-focused research periods. Giving center stage to the evolution of scientific concepts and theories allows science students to appreciate that knowledge-making processes are the result of contributions of several agents over long periods of time. These processes have to be presented within a contextualist framework in order to avoid the internalist and whiggish narratives that were so common in earlier historical studies. I believe that the active, self-aware deployment of storytelling techniques is crucial both to construct such pedagogies and to engage students in learning.

HISTORICAL STORYTELLING AS THE CORE OF SCIENCE EDUCATION

Storytelling has recently been recognized as a powerful means for improving learning about science. Science communicators and pedagogues have started to assess its potential in different contexts.[5] But how can we build stories focused primarily on the long-term evolution of concepts,

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Brush was actually arguing in his article for science teachers to avoid historical research *if they wanted to stick to a positivist view of science*: Stephen G. Brush, "Should the History of Science Be Rated X?" *Science*, 1974, *183*:1164–1172.

[2] The 2005 Special Eurobarometer survey showed that 50 percent of European citizens thought that "science classes at school are not sufficiently appealing": Liborio Dibattista and Francesca Morgese, "Incorporation of HPS/NOS Content in School and Teacher Education Programmes in Europe," in *International Handbook of Research in History, Philosophy, and Science Teaching*, 3 vols., ed. Michael R. Matthews (Dordrecht: Springer, 2014), Vol. 3, pp. 2083–2111, on p. 2085.

[3] Stephen G. Brush, "Suggestions for the Study of Science," in *Positioning the History of Science*, ed. Kostas Gavroglu and Jürgen Renn (Dordrecht: Springer, 2007), pp. 13–25, on p. 14.

[4] These communities are the International History, Philosophy, and Science Teaching Group (IHPST) and the Inter-Divisional Teaching Commission of the International Union of History and Philosophy of Science and Technology (IDTC/IUHPST). For an overview of the development of historical case studies for the classroom see Michael P. Clough, "Teaching and Learning about the Nature of Science," *Science and Education*, 2018, 27:1–5.

[5] In science communication see Marina Joubert, Lloyd Davis, and Jenni Metcalfe, "Storytelling: The Soul of Science Communication," *Journal of Science Communication*, 2019, *18*(5), https://doi.org/10.22323/2.18050501. In science education see Stephen Klassen and Cathrine Froese Klassen, "Science Teaching with Historically Based Stories: Theoretical and Practical Perspectives," in *International Handbook of Research in History, Philosophy, and Science Teaching*, ed. Matthews (cit. n. 2), Vol. 2, pp. 1503–1529.

rather than the contributions of one or a few scientists? To be sure, it is impossible to follow every step of the scientists' thought processes or to analyze every connection to their practices, but it is also not necessary. What is essential is to focus on crucial episodes that advanced research in significant ways and weave them together so that they sustain the flow of long-term narratives. These episodes need not be fictional: historians have already narrated plenty of them. In fact, historians share with science communicators and like-minded pedagogues a wealth of experience in using storytelling techniques to construct engaging narratives. Why not use it?

In order to show how storytelling techniques can be applied to science education, let us take a fundamental concept from biology: evolution. Charles Darwin's theory of natural selection had an unquestionable scientific impact in reshaping this concept. It will be the theme of our story. We can present it by constructing a narrative arc (beginning–middle–end). In this way, we will need to tell how evolution was understood *before* the theory appeared (beginning), *how* the theory came to be (middle), and what changed *after* it was published (end).

The beginning part of the story will require explaining why creationism was such an important part of the pre-Darwinian world. We do not need to present an extensive list of creationists and discuss the specificities of each of their views. Rather, we can simply pick a few examples that were representative for a given period. As part of the narration, we can even bring students in contact with primary sources that reveal the logical structure of creationist thought, such as William Paley's famous watchmaker analogy:

> In crossing a heath, suppose I pitched my foot against a *stone*, and were asked how the stone came to be there, I might possibly answer, that it had lain there forever. But suppose I had found a *watch* upon the ground, and it should be inquired how the watch happened to be in that place, I should hardly think of the answer which I had before given, that the watch might have always been there. Yet why should not this answer serve for the watch, as well as for the stone? When we come to inspect the watch, we perceive—what we could not discover in the stone—that its several parts are framed and put together for a purpose. This mechanism being observed, the inference, we think, is inevitable; that the watch must have had a maker; that there must have existed, at some time and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use.[6]

This short excerpt shows how an archetypal creationist argument was constructed. We could thus interrupt the narration to ask: Why do we tend to see stones and watches as fundamentally different? What was Paley's analogy? How could we apply it to things such as trees' roots, fishes' fins, and birds' wings? These questions stimulate students' critical thinking, and the pedagogical potential of Paley's analogy has already been recognized.[7] In science education, the main purpose of using such an example would be to explain why the views were perceived as coherent *in their historical context*, before Darwin's contribution. Students need not read Paley's *Natural Theology* in its entirety to understand his argument. They can grasp it by analyzing brief but crucial passages, as long as these are heavily complemented by what historians have said about the context in which they appeared.[8] Students' engagement can be further

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[6] Abridged from William Paley, *Natural Theology* (Philadelphia: John Morgan, 1802), pp. 1–3.

[7] See, e.g., T. Ryan Gregory, "The Argument from Design: A Guided Tour of William Paley's *Natural Theology* (1802)," *Evolution: Education and Outreach*, 2009, 2:602–611.

[8] See Topic 2 in the syllabus, available in the supplementary materials of the online edition at https://doi.org/10.1086/711126.

strengthened if topics are connected to issues of current relevance (the creationism/evolutionism divide, for example).[9]

The middle part of the story will present the main steps that led to the theory of evolution by natural selection. In this case Darwin will be our main character, but we need to contextualize his proposals and show how his work relied on the work of others. Narrating the personal stories of achievement and failure of science practitioners engages the students emotionally by immersing them in the scientists' lives and times. Such a strategy addresses students in their capacities for imagination, allowing them to experience the development of scientific ideas more vividly.[10] Darwin's thought must be related to the beginning of our story about evolution by showing the ways in which the results of the *Beagle* voyage challenged creationist discourse—and then go beyond it by explaining how he reached the concept of natural selection and integrated it in a new theory. As an example, let us take a significant moment in Darwin's work, as described by the historian Janet Browne:

> On 14 March 1837, Darwin went to hear Gould talk at the Zoological Society about his South American "ostriches." The "Avestruz Petise," he learned, was not simply a geographical variety of the ordinary rhea as he thought. Gould found sufficient differences to consider it a separate species. The taxonomist called it *Rhea darwinii*. Afterwards, the blushing discoverer stood up to read some notes about the rheas' eggs. The distribution of the two species, he said, showed that the *Petise* took the place of the common rhea in southern Patagonia. Darwin was tantalized by the week's results. Why should two closely similar rheas agree to split the country between them? Why should different finches inhabit identical islets? Suddenly, he caught at a parallel between what the rheas and finches expressed about the modern world and what his fossils were telling him. Where the birds were linked by being spread over a cluster of neighboring islands, the extinct South American mammals seemed to be connected to modern species in a chronological sense.[11]

We could then ask students: Given that natural theologians said that each organism lived in a unique environment, do Darwin's findings support creationism? Why or why not? Can we think of an alternative explanation that ties modern rheas to the evidence of fossils and their geographical distribution?[12] Like the first excerpt, which relied on a primary source, this second one can be useful in science education *even though it derives from a historical study*, as long as it is sufficiently contextualized to reveal knowledge-building processes.

The end part of the story will discuss how the theory was made public and how the scientific community responded to it. The story's narrative should always be brought to an end so that students understand that a theory has a unity and forms a trustworthy explanation in a given historical context. The theory's importance can be shown by giving examples of research avenues it opened. But a scientific theory is always incomplete, since it leaves some questions unanswered, and students also need to appreciate this inherent incompleteness. The unanswered questions leave open narrative strands that are useful in a pedagogical context because they can serve as the beginning of a new story. For example, showing Darwin's later attempts to explain

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[9] On current challenges see Graeme Gooday, John M. Lynch, Kenneth G. Wilson, and Constance K. Barsky, "Does Science Education Need the History of Science?" *Isis*, 2008, 99:322–330.

[10] I have been inspired by the work on imaginative education at Simon Fraser University. See http://www.circesfu.ca/.

[11] Abridged from Janet Browne, *Charles Darwin: Voyaging* (Princeton, N.J.: Princeton Univ. Press, 1995), pp. 360–361.

[12] See Topic 5 in the syllabus, available in the supplementary materials of the online edition at https://doi.org/10.1086/711126.

how variations appeared and were passed to descendants in the form of "gemmules" can become the beginning of the story of Thomas H. Morgan's gene concept.[13]

To close a narrative by showing that *someone* arrived *somewhere* is a storytelling technique that can give students a sense of fulfillment. This and the other techniques that I have mentioned (weaving a narrative thread, building characters, unfolding the story step by step, exploring conflict, making connections to current issues) will be nothing new to historians, as they have been deploying them for centuries. My argument is that they can illuminate the processes by which scientific evidence is assembled in theories and the way the dialectical relationship between theorization and practice evolves throughout history to make what we call science.

Storytelling techniques have only recently been considered worthy of further research as a means of explaining the complex evolution of scientific knowledge. Their potential is not restricted to science education, and Bruno Latour himself has been testing it in the performing arts. In my work as a playwright, I have authored a play on phrenology's racist and misogynist claims. The spectators were deeply surprised by phrenology because they had never heard of its seemingly bizarre claims.[14] There is still much to be learned from storytelling; but if it is to work in science education, other changes are required.

NEEDS OF A SCIENCE EDUCATION INFORMED BY HISTORY

As there are as yet few, if any, pedagogical materials that incorporate historical knowledge of the sciences in the way I have described, a first aim would be to develop them, possibly in the form of textbooks. For this purpose, we need pedagogues who understand the specificities of historical knowledge of the sciences and can adapt it to pedagogical contexts of science learning, a task that will require appropriate training. Of course, textbooks can achieve little by the mere fact of their existence. Historians of science also need to ensure that science teachers are prepared to discuss historical narratives of science critically in the classroom. This means that history of science—not to mention storytelling techniques—must be recognized and implemented as an important part of their formal training. Another possibility, as various essays in this Focus section demonstrate, might be to build co-teaching partnerships between historians and scientists. But even if these goals are met, approaches such as the one described here are bound to fail if the ways in which science students are evaluated do not privilege understanding rather than dry memorization. Therefore, we will need to move away from traditional methods of evaluation as well. These are the three substantial challenges that must be met in the long run if a new kind of science education is to prove effective. Storytelling may prove useful in learning contexts for students from any educational level, but the conceptually themed approach discussed here is probably best suited for science courses in upper secondary education and universities, since it requires that students undertake complex analyses of the evolution of scientific ideas.

Historians of science can play a relevant role in such pedagogy. They have the necessary historiographical training to weave sophisticated, contextualist narratives on the evolution of knowledge. In fact, historians have been doing this for decades. What is now needed is to produce narratives that integrate their research in a format that can be easily used in pedagogical contexts. Some scholars, albeit not professional historians, have already made important contributions that show

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[13] There have been some attempts at producing such narratives, but they lack historiographical sophistication. See James Schwartz, *In Pursuit of the Gene: From Darwin to DNA* (Cambridge, Mass.: Harvard Univ. Press, 2008).

[14] On Latour's work see Andrew Todd, "Bruno Latour: 'Trump and Thunberg Inhabit Different Planets—His Has No Limits, Hers Trembles,'" *Guardian*, 4 Feb. 2020. My play *The Science of the Future* was presented in the Anthropocene Campus Lisbon: Parallax, a part of the Anthropocene Curriculum initiated by the Haus der Kulturen der Welt and the Max Planck Institute for the History of Science.

us what this format could look like.[15] Moreover, the longer-term narratives on the evolution of science that will be produced in this context will also respond to some of the concerns that have been raised in the historians' community in the last decades, of which *The History Manifesto* is currently the best known and most controversial example.[16]

I believe that there is an opportunity, still largely unexplored, to bring historians of science and science pedagogues together to work toward a common goal. This can be turned into a sustained collaboration because new historical knowledge has to be periodically incorporated in historically informed pedagogical narratives. If there is a future for such partnership, then we might create another career path for historians. Speaking as a historian, nothing would give me more professional and personal satisfaction than using my knowledge to engage students in learning more fully and provide them with a deeper understanding of science.

[15] In psychology see Tracy B. Henley, *Hergenhahn's An Introduction to the History of Psychology* (Boston: Cengage, 2019). In organic chemistry see Mark M. Green, *Organic Chemistry Principles in Context: A Story-Telling Historical Approach* (New York: ScienceFromAway, 2012).

[16] Jo Guldi and David Armitage, *The History Manifesto* (Cambridge: Cambridge Univ. Press, 2014). Various authors have analyzed it in "Viewpoint: *The History Manifesto* and the History of Science," *Isis*, 2016, *107*:309–357.